
SECTION 5

POLLUTANT UPTAKE DATA ANALYSIS

Statistical comparison of pollutant uptake data sets reveal differential trends in pollutant assimilation and storage over time, from species to species, from matrix to matrix, and from experimental to control sites. This section discusses these trends in detail.

STATISTICAL METHODS

The data sets consist of the pollutant concentrations of the matrix (root, shoot, or soil) samples from each plant sample per sampling event. Initial statistical analysis of the data sets calculated the mean and standard deviation of the pollutant concentrations of the sample iterations for each plant matrix. The mean values for each matrix per plant species were then combined for all three sample events to determine the underlying frequency distribution. The mean values were then log ten transformed to normalize the data for analysis of variance (ANOVA). Where ANOVA determined there were significant differences between the mean values of the sampling events, t-tests were used to support those differences and weigh their significance. Data sets for nitrogen and phosphorus proved too small for transformation and were treated nonparametrically.

The results of all pollutant analyses discussed in this report are in units of parts per million (ppm) or milligrams per kilogram (mg/kg), dry basis. Total lead and zinc values of less than 1 ppm are reported as 1 ppm, and TPH values less than 20 ppm are reported as 20 ppm for statistical purposes. All total phosphorus and Kjeldahl nitrogen values fell well above their detection limits.

POLLUTION CONCENTRATION VARIATIONS

The pollutant uptake sampling regime at the South Base pond was designed to measure the mean pollutant uptake performance for each study species. Recognizing the variation in pollutant exposure according to proximity of plants to inflows and prevalent hydrologic conditions, samples were drawn from sites distributed throughout the pond. The validity of this sampling regime was tested by comparing the relative pollutant contribution of each inflow. Soil pollutant levels from the September and October sampling events were grouped into "east" and

"west" data sets to correspond with the South Base and employee parking lot inflow locations, respectively. Mann-Whitney "U" tests were then applied to the data sets. September and October data sets were treated separately.

TPH and zinc soil levels were significantly higher in eastern pond soil samples ($p < 0.001$, $p < 0.05$) for the-September sampling. Soil lead levels did not differ appreciably from one another, although the highest soil lead concentration was found near the transit base inflow. These findings support the assumption that the transit base inflow constitutes the greater source of pollutants because of greater pollutant-generating activity and larger area than the parking lot inflow. The October soil samples further supported this assumption, with soil lead levels greater in the eastern half of the pond ($p < 0.01$). Soil TPH and zinc levels were also elevated closer to the base inflow but fell short of a $p < 0.05$ significance level. Because of the variable contributions of the inflows, distributed sampling was necessary to avoid skewing the results. *Iris pseudacorus*, however, occurred only in two discrete sites that favor low pollutant concentrations. This may partially account for the generally low matrix pollutant levels of *Iris pseudacorus* in the study. Table 5-1 shows the soil pollutant levels in the east and west halves of the pond.

| TABLE 5-1. Soil Pollutant Levels in East and West Halves of the Pond | | | |
|--|---------------------------------|---------------------------------|-------------------------|
| Pollutant | Median Level (ppm) East Half | Median Level (ppm) West Half | Mann-Whitney p Value |
| September 1991 | | | |
| TPH | 7,100.0 | 620.0 | 0.0003 |
| Pb | 83.0 | 34.0 | 0.2954 |
| Zn | 220.0 | 130.0 | 0.0424 |
| October 1991 | | | |
| TPH | 830.0 | 360.0 | 0.0564 |
| Pb | 62.0 | 32.0 | 0.0034 |
| Zn | 170.0 | 150.0 | 0.0600 |
| Combined September/October 1991 | | | |
| TPH | 985.0 (wet) | 2,050.0 (dry) | 0.8852 |
| Pb | 32.0 (wet) | 67.5 (dry) | 0.3865 |
| Zn | 155.0 (wet) | 190.0 (dry) | 0.1939 |

The influence of water level on pollutant uptake was investigated using *Sparganium sp.* plant tissue samples from "inundated" and "dry" sites for both the September and October sampling events. The inundated sites were areas that were usually flooded. The dry sites represented areas of generally less frequent flooding. Mann-Whitney "U" tests revealed that *Sparganium sp.* absorbed similar levels of TPH, lead, and zinc regardless of whether the site was dry or inundated.

Experimental to Reference Site Variations

The September sampling of pond and reference control sites provided the central data base for the pollutant uptake study. cursory comparison of the matrix samples from the pond site to the controls for *Typha latifolia*, *Sparganium sp.*, *Scirpus acutus*, *Eleocharis ovata*, and *Iris pseudacorus* shows that overall the levels of TPH, lead, and zinc were higher in the pond site matrices (Table 5-2).

Soil samples from the pond site had far greater TPH concentrations than the control sites for all plants ($p < 0.05$ or $p < 0.01$) except *Iris pseudacorus*, where there was no significant difference. Soil zinc levels in the pond samples exceeded those in the control samples for all plants ($p < 0.01$ or $p < 0.05$). Soil lead concentrations varied between control and pond according to species. Soils from *Sparganium sp.* and *Iris pseudacorus* showed no strong differences between the pond and control sites. This may be partially explained by above-normal levels of lead in the soil samples of *Sparganium sp.* and *Iris pseudacorus* from the control site. *Eleocharis ovata* soils retained significantly greater concentrations of lead than *Eleocharis ovata* soils from the nursery controls ($p < 0.01$). Refer to Table 5-3 and Figures 5-1 through 5-3 for a comparison of pollutant levels in different plant matrices.

All plants except *Scirpus acutus* retained concentrations of TPH in their root tissues moderately elevated above their control site counterparts. *Typha latifolia* root tissues accumulated mean levels of TPH at the pond site of 2,000 ppm but these did not depart significantly from the control site levels. Root levels of zinc were distinctively higher in pond samples for *Typha latifolia*, *Sparganium sp.*, and *Eleocharis ovata* ($p < 0.05$ or $p < 0.01$), while *Iris pseudacorus* and *Scirpus acutus* root concentrations of zinc did not significantly depart from those of the controls. *Sparganium sp.* root tissue levels of zinc were the highest for the September sampling event, with 203 ppm. Root tissue lead concentrations followed the same pattern as zinc, with both *Iris pseudacorus* and *Scirpus acutus* pond samples

TABLE 5-2. Comparison of Pollutant Levels In Different Plant Matrices for South Base Pond and Control Sites (September 1991)

| Matrix | TPH | Pb | Zn |
|-------------------------|--|--|---|
| <i>Typha latifolia</i> | | | |
| Soil | Variable in pond, but >> control | Variable in pond, but > control | Variable in pond, but > control |
| Root | Pond > control | Pond > control (in most samples) | Pond > control |
| Shoot | Pond > control (in most samples) | At detection limit in both pond and control | Pond > control (in most samples) |
| <i>Sparganium sp.</i> | | | |
| Soil | Pond >> control | No consistent trend | Pond > control |
| Root | Pond > control | Pond >> control | Pond > control |
| Shoot | Pond > control | Pond > control (in most samples) | Pond > control |
| <i>Scirpus acutus</i> | | | |
| Soil | Pond >> control | Pond > control | Pond > control |
| Root | No difference | Pond > control (but low values) | Variable values in pond—no clear evidence of uptake |
| Shoot | Pond > control | At detection limit in both pond and control | Slightly elevated in pond |
| <i>Eleocharis ovata</i> | | | |
| Soil | Pond >> control | Variable in pond, but in general >> control | Pond > control |
| Root | Pond > control (in most samples) | Variable in pond, but in general >> control | Pond > control |
| Shoot | Pond > control | Little difference, with most levels close to detection limit | Pond > control |
| <i>Iris pseudacorus</i> | | | |
| Soil | Little difference, with one high value in pond | No consistent trend | Pond > control |
| Root | Pond > control (in most samples) | Little difference, with most values close to detection limit | No difference |
| Shoot | No difference | At detection limit in both pond and control | No difference |

| TABLE 5-3. T-Test Probability Values For Control vs Pond Samples by Matrix Using September 1991 Data | | | |
|---|-------|-------|-------------|
| Plant | Soil | Root | Shoot |
| TPH | | | |
| <i>Iris pseudacorus</i> | 0.290 | 0.220 | 0.630 |
| <i>Typha latifolia</i> | 0.034 | 0.074 | 0.200 |
| <i>Sparganium sp.</i> | 0.011 | 0.280 | 0.001 |
| <i>Scirpus acutus</i> | 0.002 | 0.960 | 0.001 |
| <i>Eleocharis ovata</i> | 0.000 | 0.750 | 0.000 |
| Pb | | | |
| <i>Iris pseudacorus</i> | 0.630 | 0.390 | Not defined |
| <i>Typha latifolia</i> | 0.460 | 0.390 | Not defined |
| <i>Sparganium sp.</i> | 0.630 | 0.002 | 0.230 |
| <i>Scirpus acutus</i> | 0.160 | 0.150 | 0.160 |
| <i>Eleocharis ovata</i> | 0.001 | 0.000 | Not defined |
| Zn | | | |
| <i>Iris pseudacorus</i> | 0.008 | 0.330 | 0.032 |
| <i>Typha latifolia</i> | 0.033 | 0.009 | 0.035 |
| <i>Sparganium sp.</i> | 0.002 | 0.021 | 0.001 |
| <i>Scirpus acutus</i> | 0.002 | 0.079 | 0.001 |
| <i>Eleocharis ovata</i> | 0.004 | 0.021 | 0.000 |

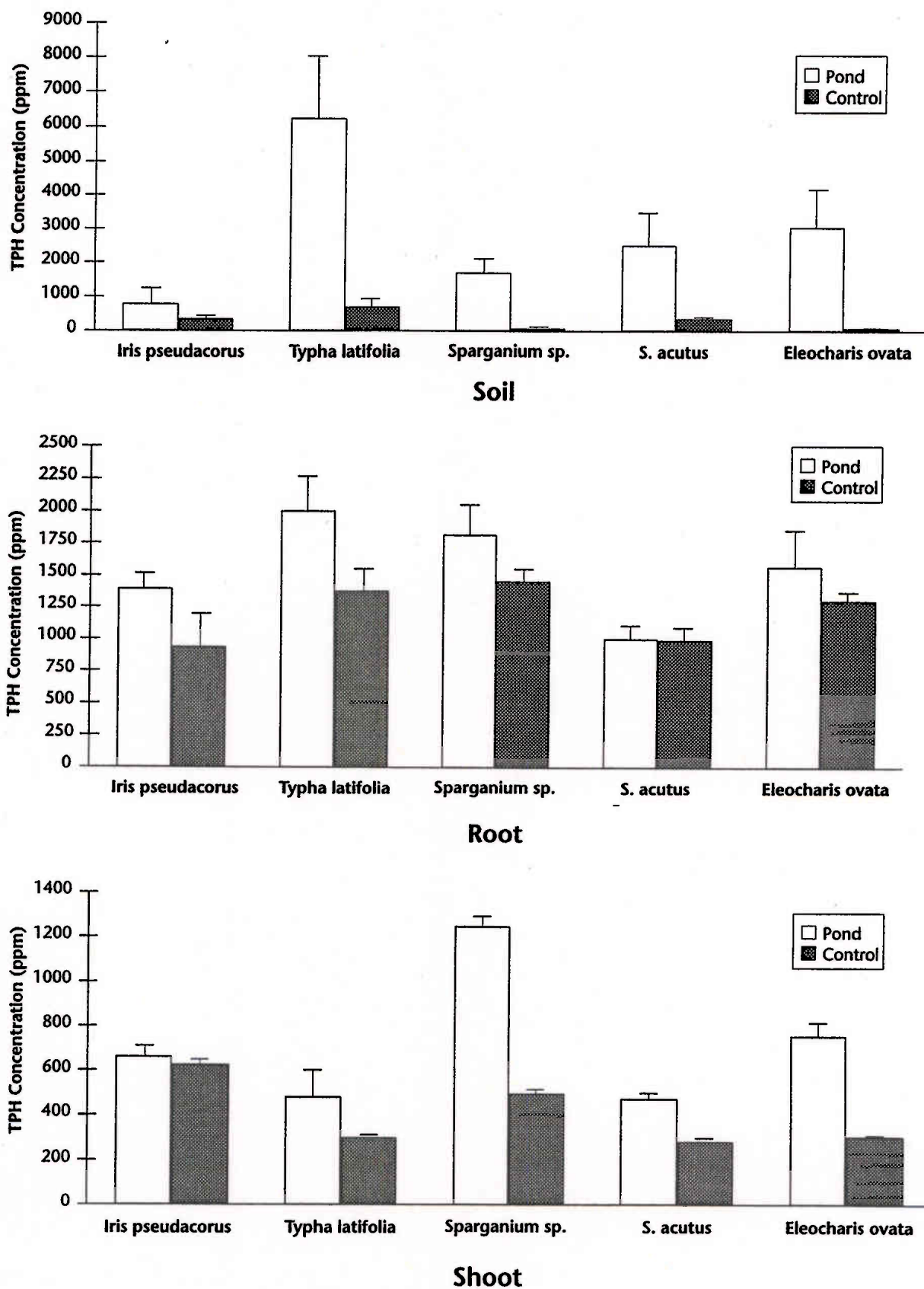


Figure 5-1. TPH Concentrations for Pond and Control Sites

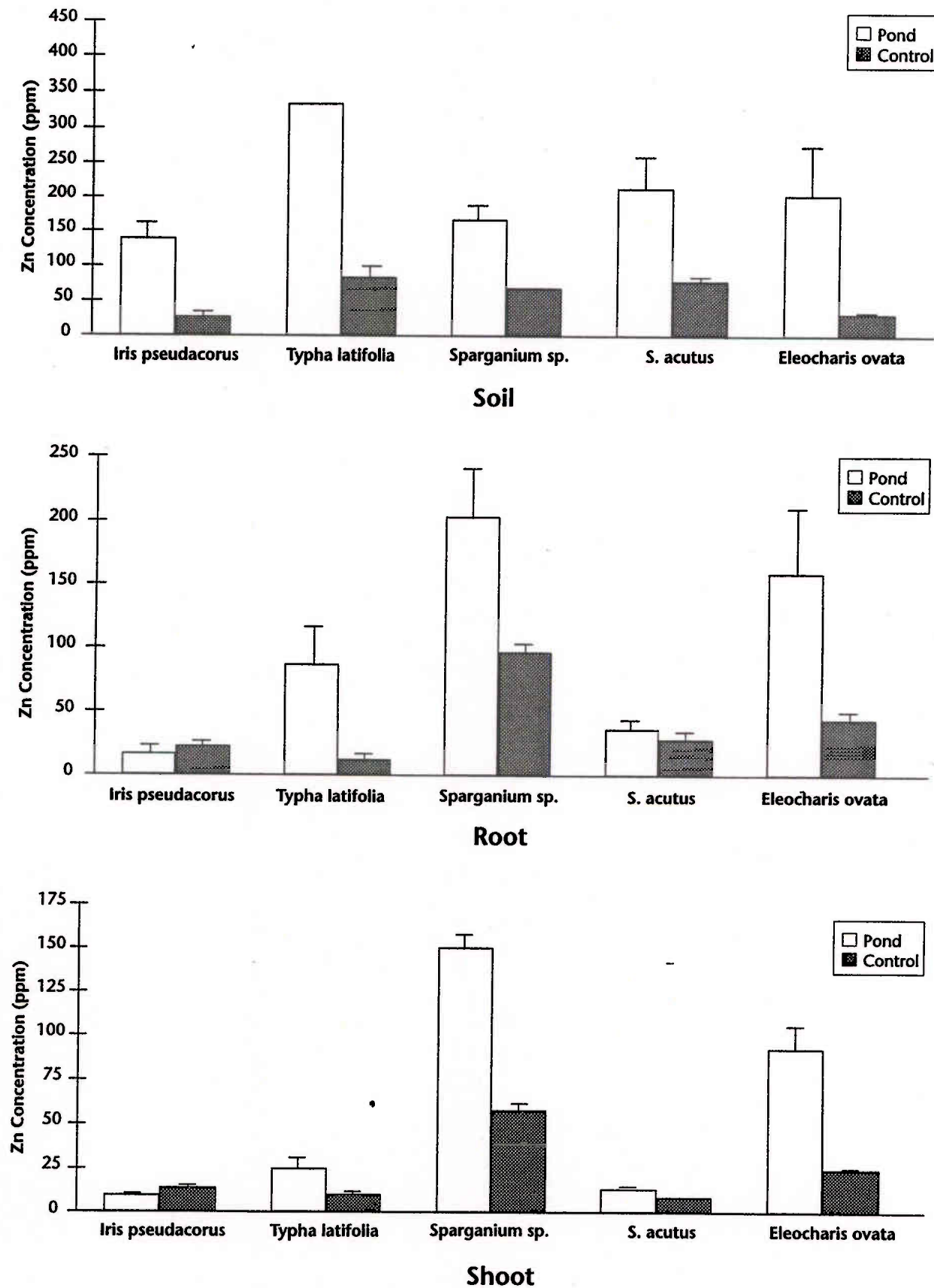


Figure 5-2. Zinc Concentrations for Pond and Control Sites

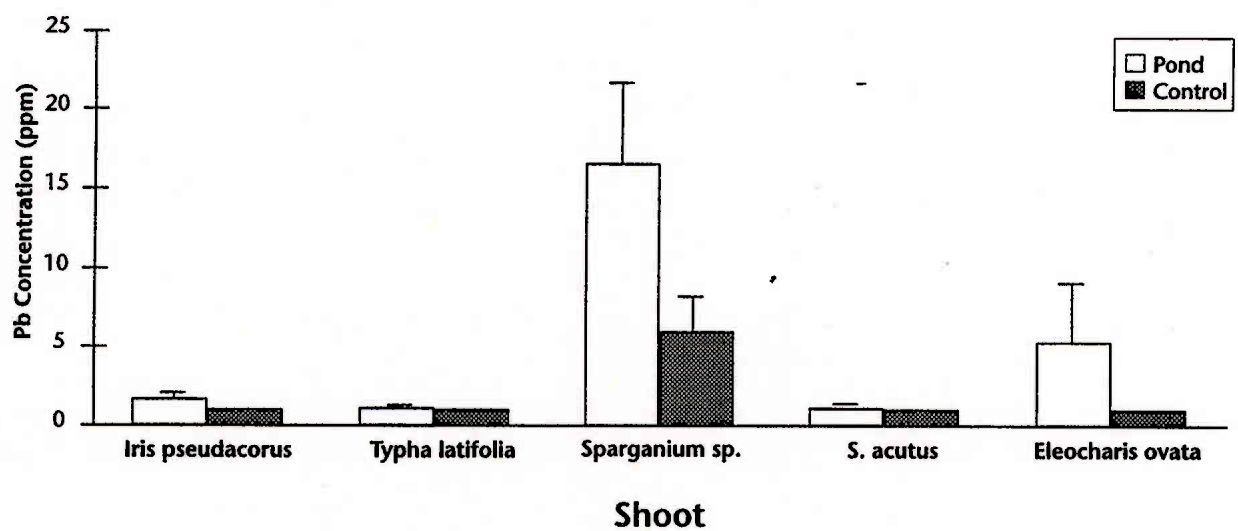
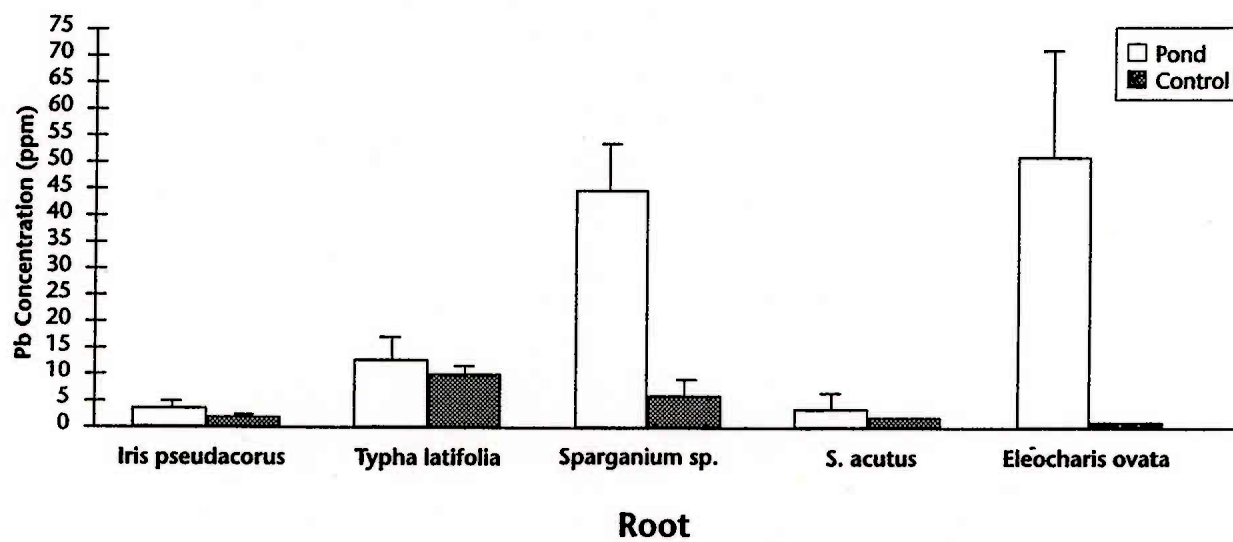
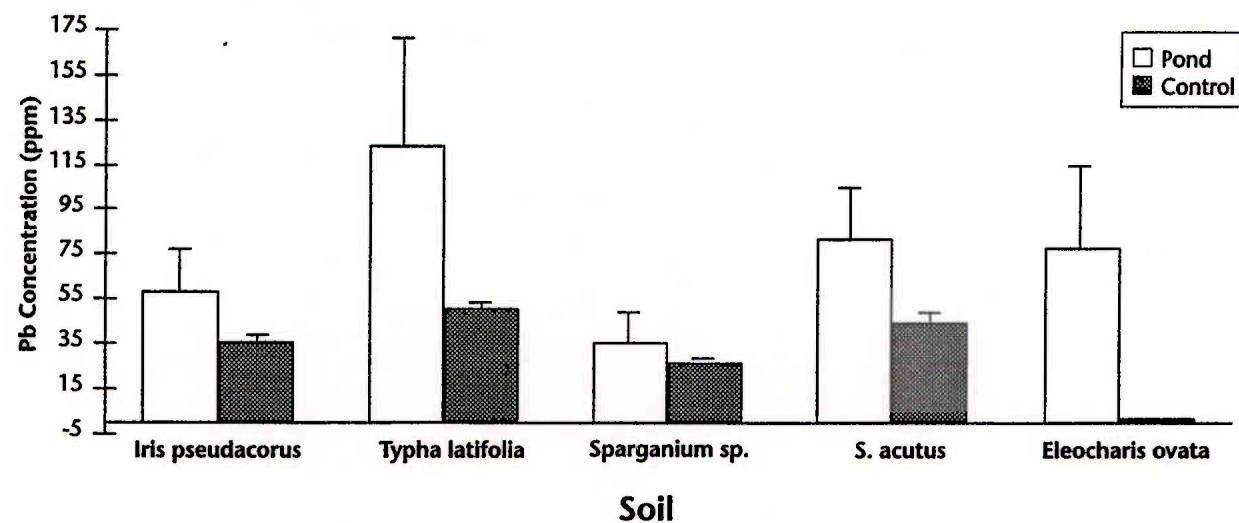


Figure 5-3. Lead Concentrations for Pond and Control Sites

showing little difference from the controls, with concentrations at or near the detection level. *Sparganium sp.* and *Eleocharis ovata* pond samples assimilated markedly greater levels of lead in their roots than the controls ($p < 0.01$ or $p < 0.001$). *Eleocharis ovata* root tissues from the pond samples had more than 30 times the levels of lead in the control root samples.

Shoot tissue pollutant concentrations displayed interesting results. In general, shoot tissues stored far less TPH, lead, and zinc than did the root tissues. Shoot TPH levels for all pond samples did not differ significantly from the control shoot tissue levels. *Sparganium sp.* and *Eleocharis ovata* from the pond had shoot tissue lead concentrations that surpassed the control shoot tissue lead concentrations. Pond *Typha latifolia*, *Iris pseudacorus*, and *Scirpus acutus* shoot tissues showed lead concentrations similar to the control samples, near the detection limit. Levels of zinc in pond sample shoot tissues follow a pattern similar to the root tissue zinc levels, with *Sparganium sp.* and *Eleocharis ovata*, and, to a lesser extent, *Typha latifolia* exhibiting higher levels than the controls. Neither *Iris pseudacorus* nor *Scirpus acutus* pond samples departed meaningfully from the control samples for shoot tissue zinc concentrations. Figures 5-4 through 5-6 and Tables 5-4 through 5-6 show pollutant concentrations for individual sampling dates.

Temporal Variations

As a general trend, pollutant concentrations declined in matrix samples from the pond across the July, September, and October sampling events. As shown in Table 5-7, soil TPH levels reduced markedly over time for all plants, especially *Sparganium sp.*, which dropped 700 percent in soil TPH levels from July to September ($p < 0.05$). Root TPH levels dropped significantly for *Typha latifolia* and *Sparganium sp.* from July to September and to a lesser extent for *Scirpus acutus*. *Iris pseudacorus* and *Eleocharis ovata* root tissue TPH levels varied little over time, with slight decreases from July to September followed by a resurgence to or exceeding July TPH levels in October. *Scirpus acutus* especially reflected this trend, with October root TPH concentrations matching July levels after a strong decrease in September ($p < 0.01$ in both cases). Shoot TPH concentrations fell uniformly from September to October for all species ($p < 0.05$ to $p < 0.001$). *Sparganium sp.* decreased most significantly over this time, falling from 1,250 ppm to 513 ppm. In contrast, July to September changes in shoot tissue TPH levels showed no clear trend. TPH levels in *Typha latifolia* and *Iris pseudacorus* shoot tissues clearly decreased, while those in *Sparganium sp.*, *Eleocharis ovata*, and *Scirpus acutus* increased over this time, but not significantly.

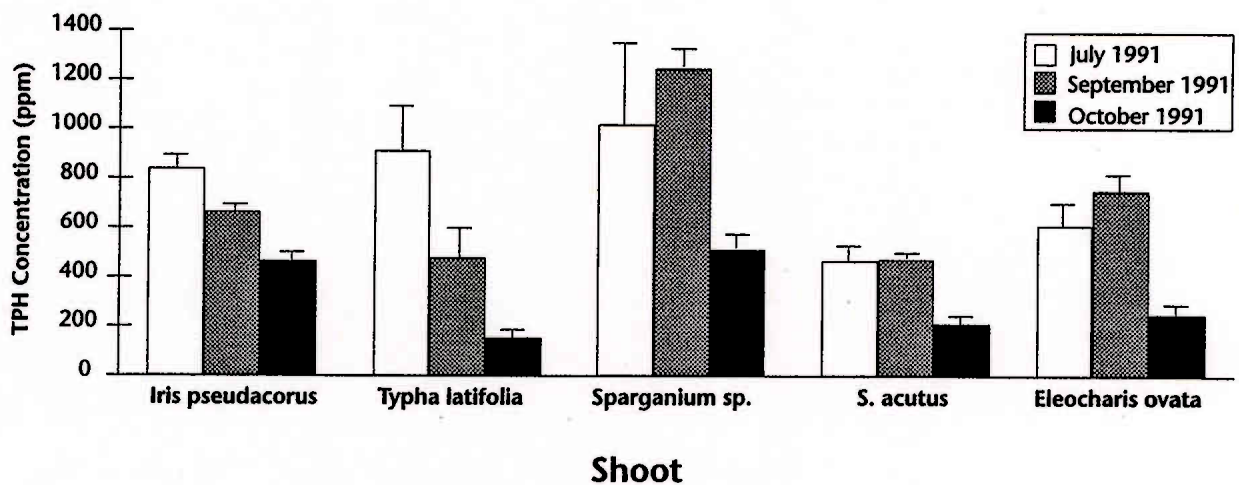
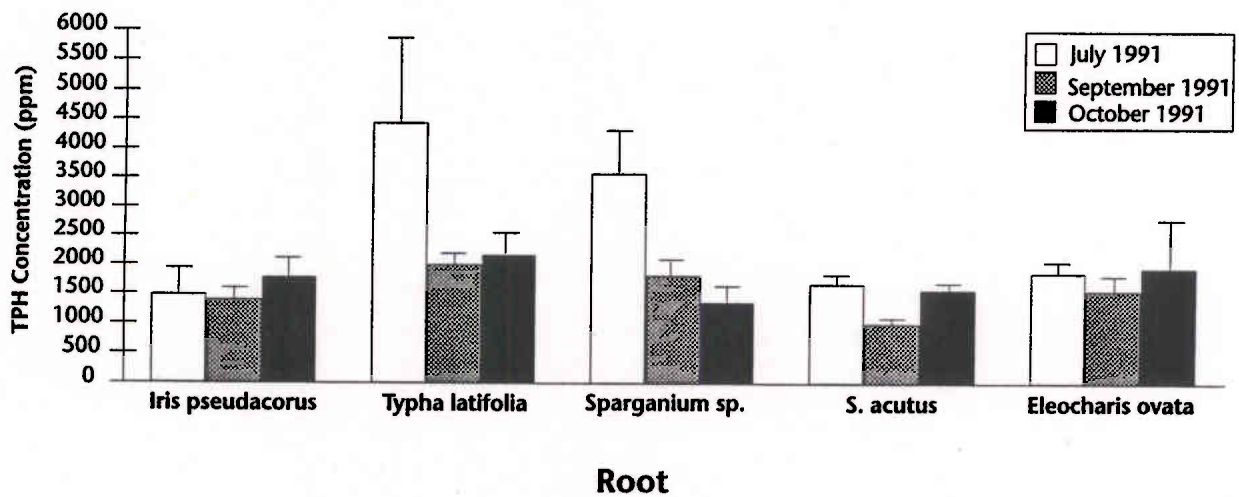
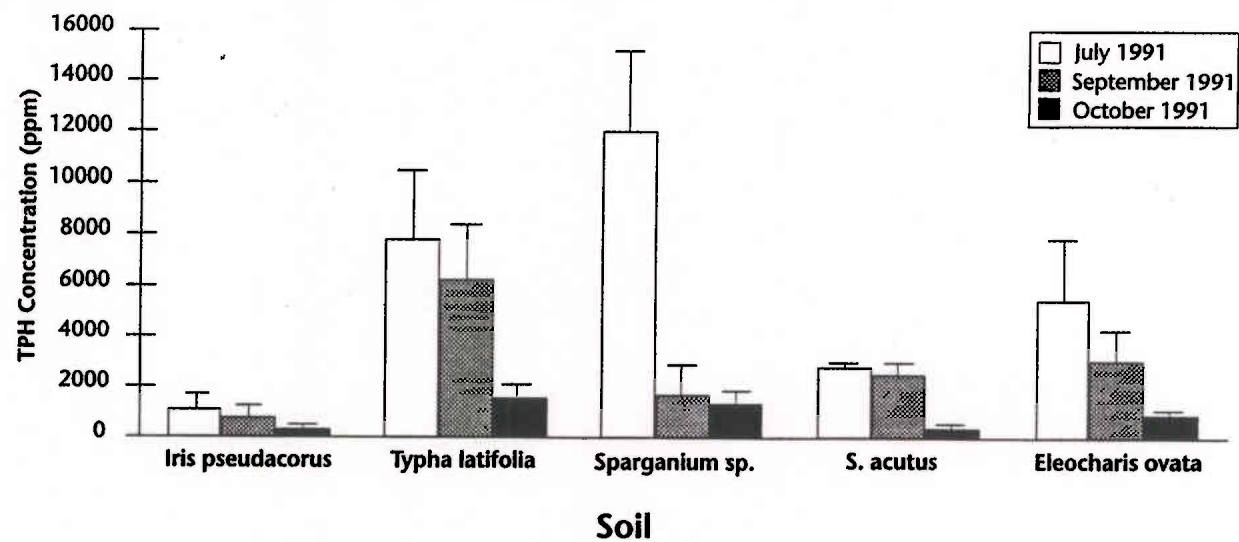


Figure 5-4. Matrix TPH Concentrations for Individual Sampling Dates

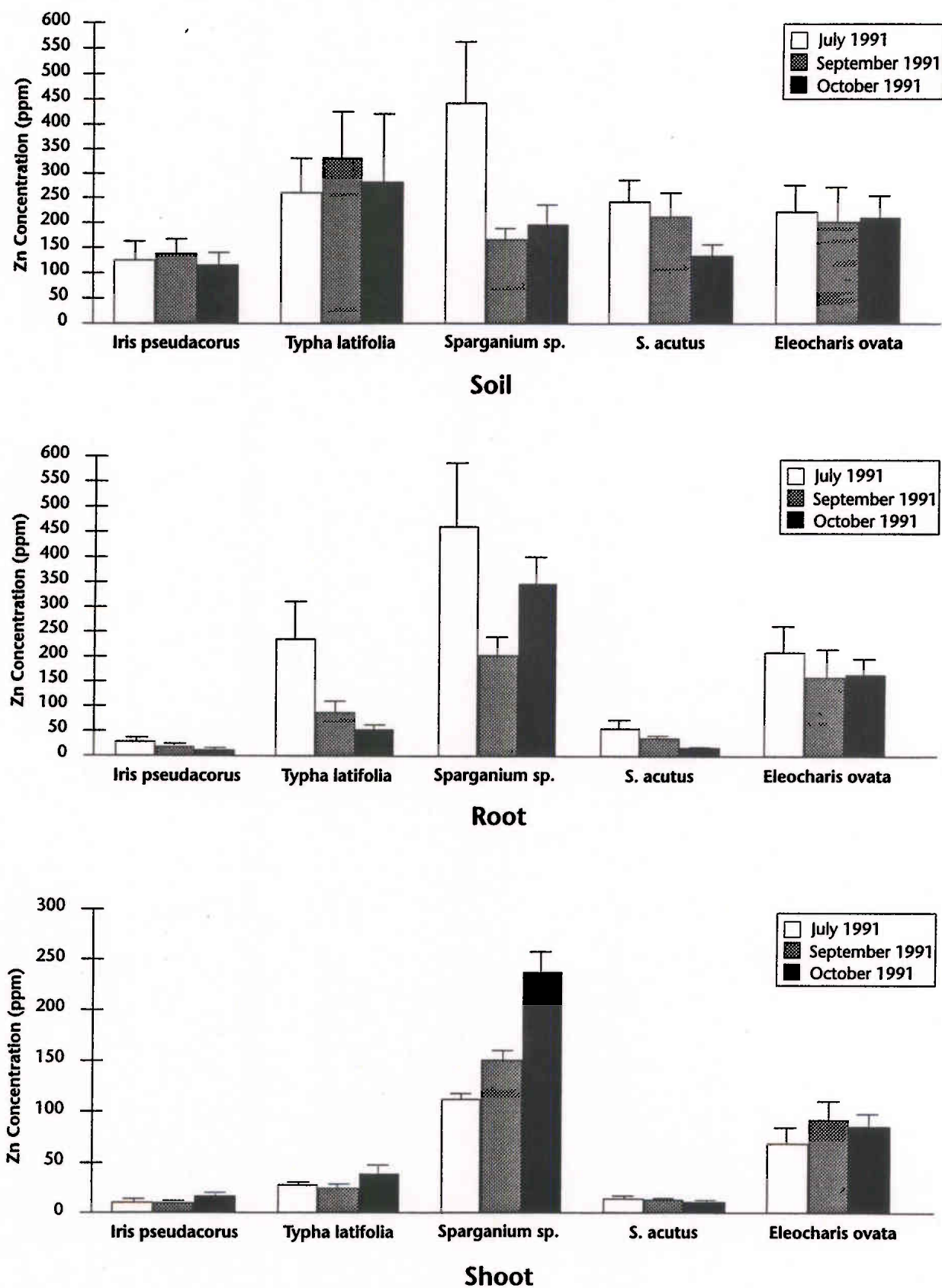


Figure 5-5. Matrix Zinc Concentrations for Individual Sampling Dates

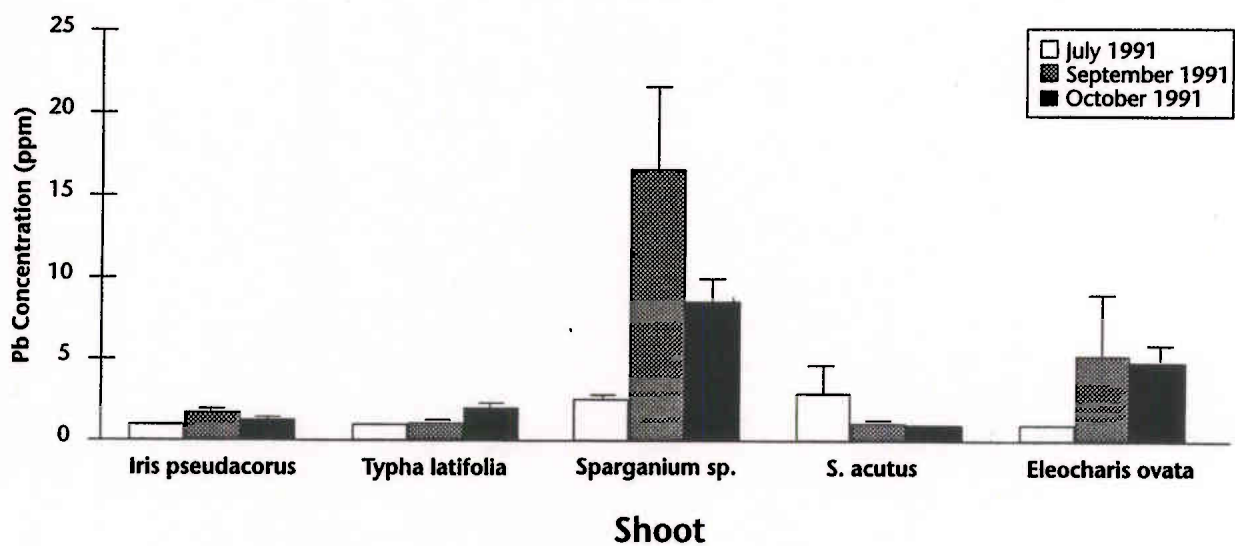
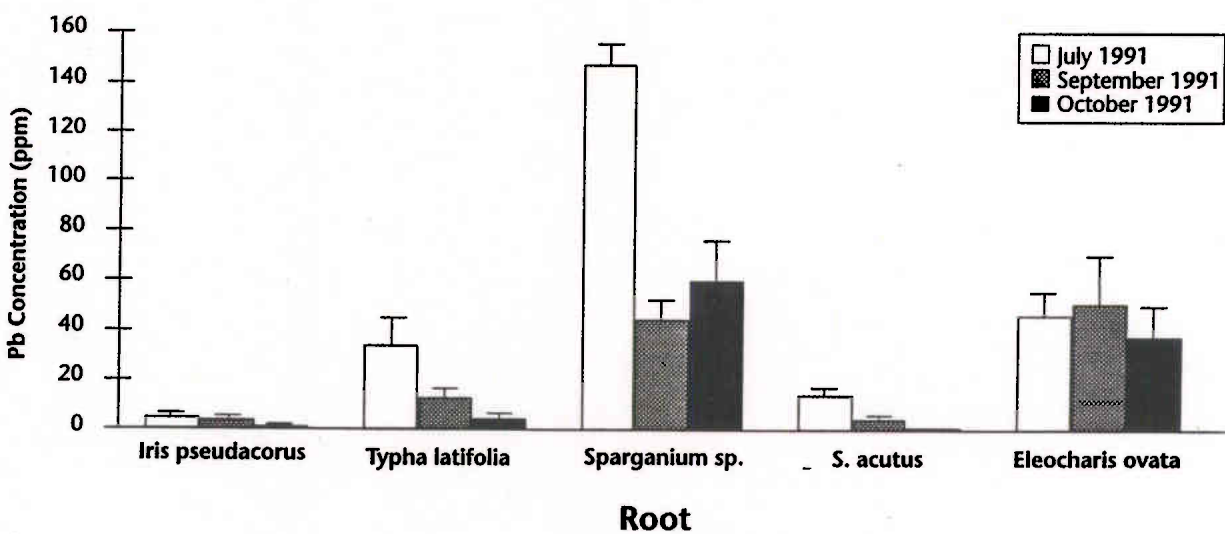
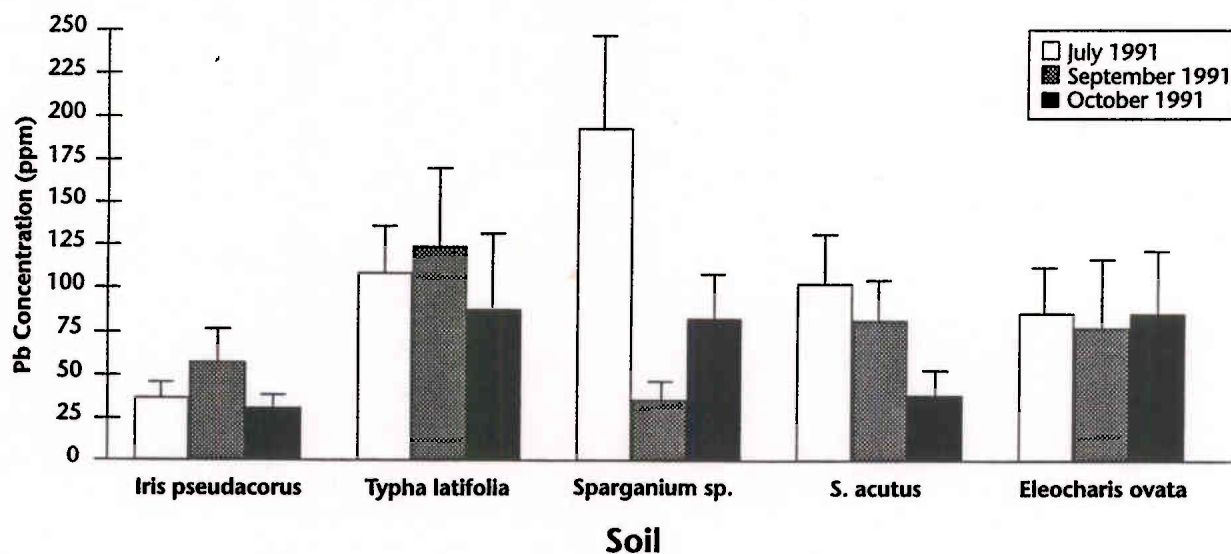


Figure 5-6. Matrix Lead Concentrations for Individual Sampling Dates

TABLE 5-4. Summary of TPH Concentrations for Individual Sampling Dates

| Plant | Sampling Date | Mean | Standard Deviation | Standard Error | Minimum Value | Maximum Value |
|---------------------------|---------------|----------|--------------------|----------------|---------------|---------------|
| Soil Concentrations (ppm) | | | | | | |
| <i>Iris pseudacorus</i> | July 1991 | 1,100.0 | 1,035.0 | 598.0 | 420.0 | 2,300.0 |
| | Sept 1991 | 794.0 | 1,029.0 | 389.0 | 210.0 | 3,100.0 |
| | Oct 1991 | 312.0 | 370.0 | 140.0 | 20.0 | 1,100.0 |
| <i>Typha latifolia</i> | July 1991 | 7,800.0 | 4,623.0 | 2,669.0 | 2,500.0 | 11,000.0 |
| | Sept 1991 | 6,257.0 | 5,398.0 | 2,040.0 | 400.0 | 14,000.0 |
| | Oct 1991 | 1,569.0 | 1,494.0 | 565.0 | 210.0 | 4,300.0 |
| <i>Sparganium sp.</i> | July 1991 | 12,000.0 | 5,568.0 | 3,215.0 | 6,000.0 | 17,000.0 |
| | Sept 1991 | 1,697.0 | 1,059.0 | 400.0 | 870.0 | 3,500.0 |
| | Oct 1991 | 1,370.0 | 1,105.0 | 418.0 | 360.0 | 3,100.0 |
| <i>Scirpus acutus</i> | July 1991 | 2,800.0 | 1,300.0 | 751.0 | 2,000.0 | 4,300.0 |
| | Sept 1991 | 2,526.0 | 2,741.0 | 1,036.0 | 880.0 | 8,600.0 |
| | Oct 1991 | 387.0 | 248.0 | 94.0 | 94.0 | 760.0 |
| <i>Eleocharis ovata</i> | July 1991 | 5,467.0 | 4,179.0 | 2,413.0 | 1,600.0 | 9,900.0 |
| | Sept 1991 | 3,069.0 | 3,012.0 | 1,138.0 | 470.0 | 7,500.0 |
| | Oct 1991 | 936.0 | 917.0 | 347.0 | 270.0 | 2,900.0 |
| Root Concentrations (ppm) | | | | | | |
| <i>Iris pseudacorus</i> | July 1991 | 1,480.0 | 893.0 | 515.0 | 840.0 | 2,500.0 |
| | Sept 1991 | 1,393.0 | 455.0 | 172.0 | 750.0 | 2,000.0 |
| | Oct 1991 | 1,777.0 | 952.0 | 360.0 | 520.0 | 3,100.0 |
| <i>Typha latifolia</i> | July 1991 | 4,433.0 | 2,438.0 | 1,408.0 | 2,600.0 | 7,200.0 |
| | Sept 1991 | 2,000.0 | 673.0 | 254.0 | 1,300.0 | 3,300.0 |
| | Oct 1991 | 2,167.0 | 967.0 | 366.0 | 170.0 | 3,200.0 |
| <i>Sparganium sp.</i> | July 1991 | 3,567.0 | 1,305.0 | 754.0 | 2,200.0 | 4,800.0 |
| | Sept 1991 | 1,811.0 | 625.0 | 236.0 | 980.0 | 2,700.0 |
| | Oct 1991 | 1,366.0 | 670.0 | 253.0 | 650.0 | 2,300.0 |
| <i>Scirpus acutus</i> | July 1991 | 1,667.0 | 153.0 | 88.0 | 1,500.0 | 1,800.0 |
| | Sept 1991 | 999.0 | 283.0 | 107.0 | 590.0 | 1,500.0 |
| | Oct 1991 | 1,571.0 | 325.0 | 123.0 | 1,200.0 | 2,100.0 |
| <i>Eleocharis ovata</i> | July 1991 | 1,867.0 | 321.0 | 186.0 | 1,500.0 | 2,100.0 |
| | Sept 1991 | 1,564.0 | 731.0 | 276.0 | 520.0 | 2,700.0 |
| | Oct 1991 | 1,946.0 | 2,237.0 | 846.0 | 90.0 | 6,700.0 |

TABLE 5-4. Summary of TPH Concentrations For Individual Sampling Dates (Continued)

| Plant | Sampling Date | Mean | Standard Deviation | Standard Error | Minimum Value | Maximum Value |
|-----------------------------------|---------------|---------|--------------------|----------------|---------------|---------------|
| Shoot Concentrations (ppm) | | | | | | |
| <i>Iris pseudacorus</i> | July 1991 | 843.0 | 85.0 | 49.0 | 780.0 | 940.0 |
| | Sept 1991 | 663.0 | 133.0 | 50.0 | 510.0 | 870.0 |
| | Oct 1991 | 466.0 | 106.0 | 40.0 | 310.0 | 550.0 |
| <i>Typha latifolia</i> | July 1991 | 913.0 | 430.0 | 248.0 | 450.0 | 1,300.0 |
| | Sept 1991 | 479.0 | 314.0 | 119.0 | 210.0 | 1,100.0 |
| | Oct 1991 | 156.0 | 96.0 | 36.0 | 20.0 | 300.0 |
| <i>Sparganium sp.</i> | July 1991 | 1,020.0 | 252.0 | 146.0 | 810.0 | 1,300.0 |
| | Sept 1991 | 1,250.0 | 210.0 | 79.0 | 950.0 | 1,600.0 |
| | Oct 1991 | 513.0 | 173.0 | 65.0 | 290.0 | 790.0 |
| <i>Scirpus acutus</i> | July 1991 | 470.0 | 104.0 | 60.0 | 400.0 | 590.0 |
| | Sept 1991 | 473.0 | 69.0 | 26.0 | 350.0 | 560.0 |
| | Oct 1991 | 214.0 | 65.0 | 25.0 | 86.0 | 300.0 |
| <i>Eleocharis ovata</i> | July 1991 | 613.0 | 143.0 | 83.0 | 490.0 | 770.0 |
| | Sept 1991 | 757.0 | 179.0 | 68.0 | 570.0 | 1,000.0 |
| | Oct 1991 | 253.0 | 117.0 | 44.0 | 20.0 | 400.0 |

TABLE 5-5. Summary of Zn Concentrations For Individual Sampling Dates

| Plant | Sampling Date | Mean | Standard Deviation | Standard Error | Minimum Value | Maximum Value |
|----------------------------------|---------------|-------|--------------------|----------------|---------------|---------------|
| Soil Concentrations (ppm) | | | | | | |
| <i>Iris pseudacorus</i> | July 1991 | 126.0 | 64.0 | 37.0 | 87.0 | 200.0 |
| | Sept 1991 | 139.0 | 71.0 | 27.0 | 82.0 | 290.0 |
| | Oct 1991 | 116.0 | 67.0 | 25.0 | 53.0 | 240.0 |
| <i>Typha latifolia</i> | July 1991 | 260.0 | 128.0 | 70.0 | 120.0 | 340.0 |
| | Sept 1991 | 333.0 | 249.0 | 94.0 | 91.0 | 680.0 |
| | Oct 1991 | 284.0 | 364.0 | 138.0 | 84.0 | 1,100.0 |
| <i>Sparganium sp.</i> | July 1991 | 443.0 | 206.0 | 119.0 | 230.0 | 640.0 |
| | Sept 1991 | 167.0 | 62.0 | 23.0 | 70.0 | 270.0 |
| | Oct 1991 | 197.0 | 101.0 | 38.0 | 82.0 | 390.0 |

TABLE 5-5. Summary of Zn Concentrations For Individual Sampling Dates (Continued)

| Plant | Sampling Date | Mean | Standard Deviation | Standard Error | Minimum Value | Maximum Value |
|---------------------------------------|---------------|-------|--------------------|----------------|---------------|---------------|
| Soil Concentrations (ppm) (Continued) | | | | | | |
| <i>Scirpus acutus</i> | July 1991 | 243.0 | 84.0 | 48.0 | 190.0 | 340.0 |
| | Sept 1991 | 213.0 | 117.0 | 44.0 | 120.0 | 460.0 |
| | Oct 1991 | 135.0 | 58.0 | 22.0 | 78.0 | 250.0 |
| <i>Eleocharis ovata</i> | July 1991 | 223.0 | 72.0 | 42.0 | 140.0 | 270.0 |
| | Sept 1991 | 203.0 | 180.0 | 68.0 | 46.0 | 540.0 |
| | Oct 1991 | 211.0 | 124.0 | 47.0 | 140.0 | 490.0 |
| Root Concentrations (ppm) | | | | | | |
| <i>Iris pseudacorus</i> | July 1991 | 28.0 | 13.0 | 7.5 | 20.0 | 43.0 |
| | Sept 1991 | 18.7 | 10.2 | 3.9 | 10.0 | 38.0 |
| | Oct 1991 | 11.6 | 4.8 | 1.8 | 7.0 | 21.0 |
| <i>Typha latifolia</i> | July 1991 | 235.0 | 131.0 | 76.0 | 85.0 | 330.0 |
| | Sept 1991 | 87.0 | 73.0 | 28.0 | 21.0 | 190.0 |
| | Oct 1991 | 53.0 | 30.0 | 11.0 | 16.0 | 110.0 |
| <i>Sparganium sp.</i> | July 1991 | 460.0 | 207.0 | 119.0 | 270.0 | 680.0 |
| | Sept 1991 | 203.0 | 105.0 | 40.0 | 92.0 | 400.0 |
| | Oct 1991 | 347.0 | 141.0 | 53.0 | 150.0 | 540.0 |
| <i>Scirpus acutus</i> | July 1991 | 54.7 | 27.7 | 16.0 | 29.0 | 84.0 |
| | Sept 1991 | 36.4 | 21.7 | 8.2 | 14.0 | 70.0 |
| | Oct 1991 | 17.3 | 6.0 | 2.3 | 12.0 | 29.0 |
| <i>Eleocharis ovata</i> | July 1991 | 209.0 | 85.0 | 49.0 | 140.0 | 300.0 |
| | Sept 1991 | 159.0 | 149.0 | 56.0 | 45.0 | 440.0 |
| | Oct 1991 | 164.0 | 90.0 | 34.0 | 62.0 | 310.0 |
| Shoot Concentrations (ppm) | | | | | | |
| <i>Iris pseudacorus</i> | July 1991 | 10.7 | 3.8 | 2.2 | 8.0 | 15.0 |
| | Sept 1991 | 9.9 | 3.0 | 1.1 | 6.0 | 15.0 |
| | Oct 1991 | 17.6 | 7.3 | 2.8 | 10.0 | 30.0 |
| <i>Typha latifolia</i> | July 1991 | 28.3 | 5.5 | 3.2 | 23.0 | 34.0 |
| | Sept 1991 | 24.9 | 13.5 | 5.1 | 14.0 | 50.0 |
| | Oct 1991 | 39.4 | 23.5 | 8.9 | 13.0 | 77.0 |

| TABLE 5-5. Summary of Zn Concentrations For Individual Sampling Dates (Continued) | | | | | | |
|---|---------------|-------|--------------------|----------------|---------------|---------------|
| Plant | Sampling Date | Mean | Standard Deviation | Standard Error | Minimum Value | Maximum Value |
| Shoot Concentrations (ppm) (Continued) | | | | | | |
| <i>Sparganium sp.</i> | July 1991 | 112.0 | 17.1 | -9.9 | 96.0 | 130.0 |
| | Sept 1991 | 150.7 | 36.1 | 13.6 | 95.0 | 200.0 |
| | Oct 1991 | 238.6 | 60.9 | 23.0 | 150.0 | 350.0 |
| <i>Scirpus acutus</i> | July 1991 | 14.7 | 2.1 | 1.2 | 13.0 | 17.0 |
| | Sept 1991 | 13.3 | 2.6 | 1.0 | 11.0 | 17.0 |
| | Oct 1991 | 11.1 | 2.7 | 1.0 | 8.0 | 16.0 |
| <i>Eleocharis ovata</i> | July 1991 | 69.3 | 25.4 | 14.7 | 40.0 | 85.0 |
| | Sept 1991 | 92.6 | 43.6 | 16.5 | 53.0 | 170.0 |
| | Oct 1991 | 85.9 | 34.3 | 13.0 | 56.0 | 160.0 |

| TABLE 5-6. Summary of Pb Concentrations For Individual Sampling Dates | | | | | | |
|---|---------------|-------|--------------------|----------------|---------------|---------------|
| Plant | Sampling Date | Mean | Standard Deviation | Standard Error | Minimum Value | Maximum Value |
| Soil Concentrations (ppm) | | | | | | |
| <i>Iris pseudacorus</i> | July 1991 | 37.0 | 33.0 | 19.0 | 18.0 | 75.0 |
| | Sept 1991 | 58.0 | 50.0 | 19.0 | 15.0 | 150.0 |
| | Oct 1991 | 31.0 | 28.0 | 10.0 | 11.0 | 89.0 |
| <i>Typha latifolia</i> | July 1991 | 109.0 | 55.0 | 32.0 | 47.0 | 150.0 |
| | Sept 1991 | 124.0 | 128.0 | 46.0 | 14.0 | 320.0 |
| | Oct 1991 | 88.0 | 110.0 | 42.0 | 17.0 | 330.0 |
| <i>Sparganium sp.</i> | July 1991 | 193.0 | 95.0 | 55.0 | 100.0 | 290.0 |
| | Sept 1991 | 36.0 | 32.0 | 12.0 | 4.0 | 78.0 |
| | Oct 1991 | 83.0 | 72.0 | 27.0 | 18.0 | 230.0 |
| <i>Scirpus acutus</i> | July 1991 | 103.0 | 49.0 | 29.0 | 73.0 | 160.0 |
| | Sept 1991 | 82.0 | 65.0 | 24.0 | 34.0 | 220.0 |
| | Oct 1991 | 39.0 | 38.0 | 14.0 | 7.0 | 120.0 |
| <i>Eleocharis ovata</i> | July 1991 | 86.0 | 42.0 | 24.0 | 38.0 | 110.0 |
| | Sept 1991 | 78.0 | 98.0 | 37.0 | 6.0 | 280.0 |
| | Oct 1991 | 86.0 | 95.0 | 36.0 | 37.0 | 300.0 |

TABLE 5-6. Summary of Pb Concentrations For Individual Sampling Dates (Continued)

| Plant | Sampling Date | Mean | Standard Deviation | Standard Error | Minimum Value | Maximum Value |
|----------------------------|---------------|-------|--------------------|----------------|---------------|---------------|
| Root Concentrations (ppm) | | | | | | |
| <i>Iris pseudacorus</i> | July 1991 | 4.9 | 2.0 | 1.1 | 2.7 | 6.4 |
| | Sept 1991 | 3.7 | 2.6 | 1.0 | 2.0 | 9.0 |
| | Oct 1991 | 1.1 | 0.4 | 0.1 | 1.0 | 2.0 |
| <i>Typha latifolia</i> | July 1991 | 34.0 | 21.1 | 12.2 | 14.0 | 56.0 |
| | Sept 1991 | 12.9 | 12.3 | 4.6 | 1.0 | 32.0 |
| | Oct 1991 | 4.6 | 3.2 | 1.2 | 2.0 | 11.0 |
| <i>Sparganium sp.</i> | July 1991 | 146.7 | 15.3 | 8.8 | 130.0 | 160.0 |
| | Sept 1991 | 44.7 | 24.1 | 9.1 | 12.0 | 85.0 |
| | Oct 1991 | 59.9 | 43.7 | 16.5 | 18.0 | 140.0 |
| <i>Scirpus acutus</i> | July 1991 | 14.2 | 7.4 | 4.3 | 5.7 | 19.0 |
| | Sept 1991 | 4.4 | 3.4 | 1.3 | 1.0 | 10.0 |
| | Oct 1991 | 1.0 | 0.0 | 0.0 | 1.0 | 1.0 |
| <i>Eleocharis ovata</i> | July 1991 | 46.3 | 14.5 | 8.4 | 37.0 | 63.0 |
| | Sept 1991 | 50.9 | 53.6 | 20.3 | 6.0 | 150.0 |
| | Oct 1991 | 38.0 | 28.5 | 10.8 | 8.0 | 96.0 |
| Shoot Concentrations (ppm) | | | | | | |
| <i>Iris pseudacorus</i> | July 1991 | 1.0 | 0.0 | 0.0 | 1.0 | 1.0 |
| | Sept 1991 | 1.7 | 0.8 | 0.3 | 1.0 | 3.0 |
| | Oct 1991 | 1.3 | 0.5 | 0.2 | 1.0 | 2.0 |
| <i>Typha latifolia</i> | July 1991 | 1.0 | 0.0 | 0.0 | 1.0 | 1.0 |
| | Sept 1991 | 1.1 | 0.4 | 0.1 | 1.0 | 2.0 |
| | Oct 1991 | 2.0 | 1.1 | 0.4 | 1.0 | 4.0 |
| <i>Sparganium sp.</i> | July 1991 | 2.5 | 0.4 | 0.2 | 2.2 | 2.9 |
| | Sept 1991 | 16.6 | 14.5 | 5.5 | 2.2 | 37.0 |
| | Oct 1991 | 8.6 | 4.3 | 1.6 | 3.7 | 15.0 |
| <i>Scirpus acutus</i> | July 1991 | 2.9 | 3.4 | 1.9 | 1.0 | 6.8 |
| | Sept 1991 | 1.1 | 0.4 | 0.1 | 1.0 | 2.0 |
| | Oct 1991 | 1.0 | 0.0 | 0.0 | 1.0 | 1.0 |
| <i>Eleocharis ovata</i> | July 1991 | 1.0 | 0.0 | 0.0 | 1.0 | 1.0 |
| | Sept 1991 | 5.3 | 10.0 | 3.8 | 1.0 | 28.0 |
| | Oct 1991 | 4.9 | 2.5 | 1.0 | 3.0 | 9.0 |

| TABLE 5-7. T-Test Probability Values Between TPH Concentrations Per Sampling Date | | | |
|--|------------------|-------------------------------------|--------------------------------------|
| Plant | Sampling Date | Concentration (ppm) July 1991 | Concentration (ppm) Sept. 1991 |
| Soil | | | |
| <i>Iris pseudacorus</i> | Sept. 1991 | 0.480 | |
| | Oct. 1991 | 0.075 | 0.092 |
| <i>Typha latifolia</i> | Sept. 1991 | 0.380 | |
| | Oct. 1991 | 0.031 | 0.110 |
| <i>Sparganium sp.</i> | Sept. 1991 | 0.013 | |
| | Oct. 1991 | 0.003 | 0.380 |
| <i>Scirpus acutus</i> | Sept. 1991 | 0.370 | |
| | Oct. 1991 | 0.001 | 0.001 |
| <i>Eleocharis ovata</i> | Sept. 1991 | 0.290 | |
| | Oct. 1991 | 0.058 | 0.084 |
| Root | | | |
| <i>Iris pseudacorus</i> | Sept. 1991 | 1.000 | |
| | Oct. 1991 | 0.760 | 0.660 |
| <i>Typha latifolia</i> | Sept. 1991 | 0.150 | |
| | Oct. 1991 | 0.120 | 0.760 |
| <i>Sparganium sp.</i> | Sept. 1991 | 0.084 | |
| | Oct. 1991 | 0.027 | 0.180 |
| <i>Scirpus acutus</i> | Sept. 1991 | 0.003 | |
| | Oct. 1991 | 0.460 | 0.005 |
| <i>Eleocharis ovata</i> | Sept. 1991 | 0.270 | |
| | Oct. 1991 | 0.330 | 0.650 |
| Shoot | | | |
| <i>Iris pseudacorus</i> | Sept. 1991 | 0.003 | |
| | Oct. 1991 | 0.001 | 0.012 |
| <i>Typha latifolia</i> | Sept. 1991 | 0.160 | |
| | Oct. 1991 | 0.006 | 0.001 |
| <i>Sparganium sp.</i> | Sept. 1991 | 0.300 | |
| | Oct. 1991 | 0.013 | 0.000 |

| TABLE 5-7. T-Test Probability Values Between TPH Concentrations Per Sampling Date (Continued) | | | |
|---|---------------|-------------------------------|--------------------------------|
| Plant | Sampling Date | Concentration (ppm) July 1991 | Concentration (ppm) Sept. 1991 |
| Shoot (Continued) | | | |
| <i>Scirpus acutus</i> | Sept. 1991 | 0.940 | |
| | Oct. 1991 | 0.004 | 0.001 |
| <i>Eleocharis ovata</i> | Sept. 1991 | 0.270 | |
| | Oct. 1991 | 0.028 | 0.016 |

Matrix lead concentrations over time were at or near the detection limit levels; thus, no trend was evident. As shown in Table 5-8, the only significant drop ($p < 0.01$) in soil lead concentrations came between July and September for *Sparganium sp.* Root tissue lead concentrations generally decreased from July to October. As with the soil levels, *Sparganium sp.* showed a marked decline of root lead levels from July to September but increased again in October. *Iris pseudacorus* and *Typha latifolia* root lead levels also fell significantly during the study ($p < 0.05$ or $p < 0.01$). Variations in *Scirpus acutus* and *Eleocharis ovata* root lead levels followed no significant pattern. Overall, shoot tissues contained such low levels of lead that temporal trends in levels were difficult to gauge. *Sparganium sp.* showed the greatest variability, with a sudden increase in shoot lead concentrations from July to September ($p < 0.05$).

Matrix levels of zinc followed no observable temporal patterns (Table 5-9). For lead and TPH, *Sparganium sp.* showed the greatest variability over time. Zinc concentrations in *Sparganium sp.* soil and root samples fell sharply between July and September and then rose modestly in October. *Sparganium sp.* shoot tissues showed a steady increase over this time ($p < 0.01$). Another notable trend was that zinc concentrations in *Typha latifolia* roots fell during the study, but not significantly.

Species to Species Variations

Variation in matrix pollutant levels for all five study species were examined using ANOVA and t-tests. As shown in Table 5-10, concentrations of TPH in soils associated with the study species departed from one another significantly (ANOVA $p < 0.001$). Soil zinc levels also displayed considerable variation from species to species (t-test $p < 0.05$).

| TABLE 5-8. T-Test Probability Values Between Pb Concentrations Per Sampling Date | | | |
|---|------------------|-------------------------------------|--------------------------------------|
| Plant | Sampling Date | Concentration (ppm) July 1991 | Concentration (ppm) Sept. 1991 |
| Soil | | | |
| <i>Iris pseudacorus</i> | Sept. 1991 | 0.560 | 0.210 |
| | Oct. 1991 | 0.760 | |
| <i>Typha latifolia</i> | Sept. 1991 | 0.610 | 0.660 |
| | Oct. 1991 | 0.300 | |
| <i>Sparganium sp.</i> | Sept. 1991 | 0.008 | 0.100 |
| | Oct. 1991 | 0.056 | |
| <i>Scirpus acutus</i> | Sept. 1991 | 0.360 | 0.054 |
| | Oct. 1991 | 0.021 | |
| <i>Eleocharis ovata</i> | Sept. 1991 | 0.320 | 0.440 |
| | Oct. 1991 | 0.690 | |
| Root | | | |
| <i>Iris pseudacorus</i> | Sept. 1991 | 0.340 | 0.002 |
| | Oct. 1991 | 0.038 | |
| <i>Typha latifolia</i> | Sept. 1991 | 0.062 | 0.370 |
| | Oct. 1991 | 0.022 | |
| <i>Sparganium sp.</i> | Sept. 1991 | 0.002 | 0.540 |
| | Oct. 1991 | 0.007 | |
| <i>Scirpus acutus</i> | Sept. 1991 | 0.005 | Not defined |
| | Oct. 1991 | Not defined | |
| <i>Eleocharis ovata</i> | Sept. 1991 | 0.440 | 0.920 |
| | Oct. 1991 | 0.270 | |
| Shoot | | | |
| <i>Iris pseudacorus</i> | Sept. 1991 | Not defined | 0.250 |
| | Oct. 1991 | Not defined | |
| <i>Typha latifolia</i> | Sept. 1991 | Not defined | 0.040 |
| | Oct. 1991 | Not defined | |
| <i>Sparganium sp.</i> | Sept. 1991 | 0.015 | 0.490 |
| | Oct. 1991 | 0.002 | |

| TABLE 5-8. T-Test Probability Values Between Pb Concentrations Per Sampling Date (Continued) | | | |
|--|---------------|-------------------------------|--------------------------------|
| Plant | Sampling Date | Concentration (ppm) July 1991 | Concentration (ppm) Sept. 1991 |
| Shoot (Continued) | | | |
| <i>Scirpus acutus</i> | Sept. 1991 | 0.490 | Not defined 0.180 |
| | Oct. 1991 | Not defined | |
| <i>Eleocharis ovata</i> | Sept. 1991 | Not defined | |
| | Oct. 1991 | Not defined | |

| TABLE 5-9. T-Test Probability Values Between Zn Concentrations Per Sampling Date | | | |
|---|------------------|-------------------------------------|--------------------------------------|
| Plant | Sampling Date | Concentration (ppm) July 1991 | Concentration (ppm) Sept. 1991 |
| Soil | | | |
| <i>Iris pseudacorus</i> | Sept. 1991 | 0.780 | 0.410 |
| | Oct. 1991 | 0.720 | |
| <i>Typha latifolia</i> | Sept. 1991 | 0.900 | 0.530 |
| | Oct. 1991 | 0.640 | |
| <i>Sparganium sp.</i> | Sept. 1991 | 0.067 | 0.630 |
| | Oct. 1991 | 0.100 | |
| <i>Scirpus acutus</i> | Sept. 1991 | 0.470 | 0.095 |
| | Oct. 1991 | 0.059 | |
| <i>Eleocharis ovata</i> | Sept. 1991 | 0.370 | 0.490 |
| | Oct. 1991 | 0.700 | |
| Root | | | |
| <i>Iris pseudacorus</i> | Sept. 1991 | 0.220 | 0.097 |
| | Oct. 1991 | 0.053 | |
| <i>Typha latifolia</i> | Sept. 1991 | 0.086 | 0.580 |
| | Oct. 1991 | 0.057 | |
| <i>Sparganium sp.</i> | Sept. 1991 | 0.060 | 0.051 |
| | Oct. 1991 | 0.420 | |

| TABLE 5-9. T-Test Probability Values Between Zn Concentrations Per Sampling Date (Continued) | | | |
|--|---------------|-------------------------------|--------------------------------|
| Plant | Sampling Date | Concentration (ppm) July 1991 | Concentration (ppm) Sept. 1991 |
| Root (Continued) | | | |
| <i>Scirpus acutus</i> | Sept. 1991 | 0.280 | 0.056 |
| | Oct. 1991 | 0.079 | |
| <i>Eleocharis ovata</i> | Sept. 1991 | 0.230 | 0.590 |
| | Oct. 1991 | 0.390 | |

| TABLE 5-10 ANOVA and T-Test Probability Values for Variation in Soil Pollutant Concentrations | | | | |
|---|-------------------------|------------------------|-----------------------|-----------------------|
| Plant | <i>Iris pseudacorus</i> | <i>Typha latifolia</i> | <i>Sparganium sp.</i> | <i>Scirpus acutus</i> |
| TPH Concentrations (ppm) | | | | |
| <i>Typha latifolia</i> | 0.000 | | | |
| <i>Sparganium sp.</i> | 0.000 | 0.630 | | |
| <i>Scirpus acutus</i> | 0.033 | 0.053 | 0.087 | |
| <i>Eleocharis ovata</i> | 0.002 | 0.310 | 0.530 | 0.270 |
| Zn Concentrations (ppm) | | | | |
| <i>Typha latifolia</i> | 0.007 | | | |
| <i>Sparganium sp.</i> | 0.006 | 0.610 | | |
| <i>Scirpus acutus</i> | 0.024 | 0.230 | 0.400 | |
| <i>Eleocharis ovata</i> | 0.033 | 0.360 | 0.610 | 0.810 |
| Note: ANOVA $p < 0.001$ | | | | |

Soils associated with *Iris pseudacorus* especially vary from other species' soils in TPH and zinc levels (t-test $p < 0.01$ or $p < 0.05$). This may be due to active bioaccumulation by *Iris pseudacorus* or due to the distance of the sample sites from the pollution sources (inflows). Soil lead concentrations, however, varied insignificantly from one another (ANOVA $p = 0.262$). Among the root tissues, lead and zinc levels were found to be significantly different ($p < 0.001$) for all species (Table 5-11). Root TPH concentrations did not differ significantly from species to species.

TABLE 5-11. ANOVA and T-Test Probability Values for Variation in Root Pollutant Concentrations

| Plant | <i>Iris pseudacorus</i> | <i>Typha latifolia</i> | <i>Sparganium sp.</i> | <i>Scirpus acutus</i> |
|-------------------------|-------------------------|------------------------|-----------------------|-----------------------|
| Pb Concentrations (ppm) | | | | |
| <i>Typha latifolia</i> | 0.003 | | | |
| <i>Sparganium sp.</i> | 0.000 | 0.000 | | |
| <i>Scirpus acutus</i> | 0.680 | 0.018 | 0.000 | |
| <i>Eleocharis ovata</i> | 0.000 | 0.000 | 0.083 | 0.000 |
| Zn Concentrations (ppm) | | | | |
| <i>Typha latifolia</i> | 0.000 | | | |
| <i>Sparganium sp.</i> | 0.000 | 0.000 | | |
| <i>Scirpus acutus</i> | 0.013 | 0.002 | 0.000 | |
| <i>Eleocharis ovata</i> | 0.000 | 0.014 | 0.004 | 0.000 |
| Note: ANOVA $p < 0.001$ | | | | |

Sparganium sp. and *Eleocharis ovata* root tissues clearly exceeded the other species ($p < 0.01$ to $p < 0.001$) in lead and zinc concentrations. *Sparganium sp.* had the strongest affinity for both zinc and lead, with means of 307.8 and 68.9 mg/kg, respectively.

As shown in Table 5-12, shoot tissues varied significantly from one another for all pollutants ($p < 0.001$). *Sparganium sp.* shoots had the highest mean concentrations for all pollutants, with 906 (TPH), 10.8 (lead), and 180.1 (zinc) mg/kg at significance levels from $p < 0.05$ to $p < 0.001$ (Tables 5-13, 5-14, and 5-15). Shoot zinc concentrations exhibited broadly distributed values, with t-test probability values of < 0.001 for all comparisons except *Scirpus acutus* and *Iris pseudacorus*.

Matrix to Matrix Variations

The general trend in matrix preferences for TPH, lead, and zinc for all five plant species followed, in order of decreasing preference, soil, root, then shoot. T-test analysis of matrices within each species showed that in all cases either the soil and root matrices were statistically equal in pollutant concentration or that soil pollutant levels were significantly greater than root pollutant levels (Table 5-16). *Iris pseudacorus* root matrix provided the only exception, with *Iris pseudacorus* root TPH levels exceeding soil and shoot TPH levels ($p < 0.001$), strongly suggesting active

| TABLE 5-12. ANOVA and T-Test Probability Values for Variation in Shoot Pollutant Concentrations | | | | |
|---|-------------------------|------------------------|-----------------------|-----------------------|
| Plant | <i>Iris pseudacorus</i> | <i>Typha latifolia</i> | <i>Sparganium sp.</i> | <i>Scirpus acutus</i> |
| TPH Concentrations (ppm) | | | | |
| <i>Typha latifolia</i> | 0.012 | | | |
| <i>Sparganium sp.</i> | 0.034 | 0.001 | | |
| <i>Scirpus acutus</i> | 0.001 | 0.562 | 0.000 | |
| <i>Eleocharis ovata</i> | 0.150 | 0.260 | 0.013 | 0.390 |
| Pb Concentrations (ppm) | | | | |
| <i>Typha latifolia</i> | 0.900 | | | |
| <i>Sparganium sp.</i> | 0.000 | 0.000 | | |
| <i>Scirpus acutus</i> | 0.450 | 0.410 | 0.000 | |
| <i>Eleocharis ovata</i> | 0.021 | 0.025 | 0.003 | 0.009 |
| Zn Concentrations (ppm) | | | | |
| <i>Typha latifolia</i> | 0.000 | | | |
| <i>Sparganium sp.</i> | 0.000 | 0.000 | | |
| <i>Scirpus acutus</i> | 0.810 | 0.000 | 0.000 | |
| <i>Eleocharis ovata</i> | 0.000 | 0.000 | 0.000 | 0.000 |
| Note: ANOVA $p < 0.001$ | | | | |

| TABLE 5-13. Summary of Matrix TPH Concentrations Over Sampling Period | | | | | |
|---|---------|--------------------|----------------|---------------|---------------|
| Plant | Mean | Standard Deviation | Standard Error | Minimum Value | Maximum Value |
| Soil Concentrations (ppm) | | | | | |
| <i>Iris pseudacorus</i> | 652.0 | 825.0 | 200.0 | 20.0 | 3,100.0 |
| <i>Typha latifolia</i> | 4,599.0 | 4,645.0 | 1,127.0 | 210.0 | 14,000.0 |
| <i>Sparganium sp.</i> | 3,381.0 | 4,657.0 | 1,130.0 | 360.0 | 17,000.0 |
| <i>Scirpus acutus</i> | 1,689.0 | 2,086.0 | 506.0 | 94.0 | 8,600.0 |
| <i>Eleocharis ovata</i> | 2,614.0 | 2,958.0 | 717.0 | 270.0 | 9,900.0 |

TABLE 5-13. Summary of Matrix TPH Concentrations Over Sampling Period (Continued)

| Plant | Mean | Standard Deviation | Standard Error | Minimum Value | Maximum Value |
|----------------------------|---------|--------------------|----------------|---------------|---------------|
| Root Concentrations (ppm) | | | | | |
| <i>Iris pseudacorus</i> | 1,566.0 | 743.0 | 180.0 | 520.0 | 3,100.0 |
| <i>Typha latifolia</i> | 2,498.0 | 1,457.0 | 353.0 | 170.0 | 7,200.0 |
| <i>Sparganium sp.</i> | 1,938.0 | 1,084.0 | 263.0 | 650.0 | 4,800.0 |
| <i>Scirpus acutus</i> | 1,352.0 | 409.0 | 99.0 | 590.0 | 2,100.0 |
| <i>Eleocharis ovata</i> | 1,775.0 | 1,457.0 | 353.0 | 90.0 | 6,700.0 |
| Shoot Concentrations (ppm) | | | | | |
| <i>Iris pseudacorus</i> | 614.0 | 180.0 | 44.0 | 310.0 | 940.0 |
| <i>Typha latifolia</i> | 423.0 | 376.0 | 91.0 | 20.0 | 1,300.0 |
| <i>Sparganium sp.</i> | 906.0 | 397.0 | 96.0 | 290.0 | 1,600.0 |
| <i>Scirpus acutus</i> | 366.0 | 148.0 | 36.0 | 86.0 | 590.0 |
| <i>Eleocharis ovata</i> | 524.0 | 278.0 | 67.0 | 20.0 | 1,000.0 |

TABLE 5-14. Summary of Matrix Pb Concentrations Over Sampling Period

| Plant | Mean | Standard Deviation | Standard Error | Minimum Value | Maximum Value |
|---------------------------|-------|--------------------|----------------|---------------|---------------|
| Soil Concentrations (ppm) | | | | | |
| <i>Iris pseudacorus</i> | 43.0 | 39.0 | 94.0 | 11.0 | 150.0 |
| <i>Typha latifolia</i> | 107.0 | 109.0 | 25.2 | 14.0 | 330.0 |
| <i>Sparganium sp.</i> | 83.0 | 82.0 | 19.9 | 4.0 | 290.0 |
| <i>Scirpus acutus</i> | 68.0 | 56.0 | 13.5 | 7.0 | 220.0 |
| <i>Eleocharis ovata</i> | 83.0 | 85.0 | 20.6 | 6.0 | 300.0 |
| Root Concentrations (ppm) | | | | | |
| <i>Iris pseudacorus</i> | 2.9 | 2.3 | 0.6 | 1.0 | 9.0 |
| <i>Typha latifolia</i> | 13.2 | 15.2 | 3.7 | 1.0 | 56.0 |
| <i>Sparganium sp.</i> | 68.9 | 48.9 | 11.9 | 12.0 | 160.0 |
| <i>Scirpus acutus</i> | 4.8 | 5.9 | 1.4 | 1.0 | 19.0 |
| <i>Eleocharis ovata</i> | 44.8 | 30.8 | 9.2 | 6.0 | 150.0 |

TABLE 5-14. Summary of Matrix Pb Concentrations Over Sampling Period (Continued)

| Plant | Mean | Standard Deviation | Standard Error | Minimum Value | Maximum Value |
|-----------------------------------|------|--------------------|----------------|---------------|---------------|
| Shoot Concentrations (ppm) | | | | | |
| <i>Iris pseudacorus</i> | 1.4 | 0.6 | 0.2 | 1.0 | 3.0 |
| <i>Typha latifolia</i> | 1.5 | 0.8 | 0.2 | 1.0 | 4.0 |
| <i>Sparganium sp.</i> | 10.8 | 10.7 | 2.6 | 2.0 | 37.0 |
| <i>Scirpus acutus</i> | 1.4 | 1.4 | 0.3 | 1.0 | 7.0 |
| <i>Eleocharis ovata</i> | 4.4 | 6.6 | 1.6 | 1.0 | 28.0 |

TABLE 5-15. Summary of Matrix Zn Concentrations Over Sampling Period

| Plant | Mean | Standard Deviation | Standard Error | Minimum Value | Maximum Value |
|-----------------------------------|-------|--------------------|----------------|---------------|---------------|
| Soil Concentrations (ppm) | | | | | |
| <i>Iris pseudacorus</i> | 127.0 | 65.0 | 16.0 | 53.0 | 290.0 |
| <i>Typha latifolia</i> | 300.0 | 275.0 | 67.0 | 84.0 | 1100.0 |
| <i>Sparganium sp.</i> | 228.0 | 146.0 | 35.0 | 70.0 | 640.0 |
| <i>Scirpus acutus</i> | 186.0 | 97.0 | 24.0 | 78.0 | 460.0 |
| <i>Eleocharis ovata</i> | 210.0 | 136.0 | 33.0 | 46.0 | 540.0 |
| Root Concentrations (ppm) | | | | | |
| <i>Iris pseudacorus</i> | 17.4 | 10.3 | 2.5 | 7.0 | 43.0 |
| <i>Typha latifolia</i> | 99.3 | 94.6 | 23.0 | 16.0 | 330.0 |
| <i>Sparganium sp.</i> | 307.8 | 163.6 | 39.7 | 92.0 | 680.0 |
| <i>Scirpus acutus</i> | 31.8 | 22.0 | 5.3 | 12.0 | 84.0 |
| <i>Eleocharis ovata</i> | 169.1 | 111.9 | 27.1 | 45.0 | 440.0 |
| Shoot Concentrations (ppm) | | | | | |
| <i>Iris pseudacorus</i> | 13.2 | 6.3 | 1.5 | 6.0 | 30.0 |
| <i>Typha latifolia</i> | 31.5 | 18.1 | 4.4 | 13.0 | 77.0 |
| <i>Sparganium sp.</i> | 180.1 | 68.3 | 16.6 | 95.0 | 350.0 |
| <i>Scirpus acutus</i> | 12.6 | 2.8 | 0.7 | 8.0 | 17.0 |
| <i>Eleocharis ovata</i> | 85.7 | 36.1 | 8.8 | 40.0 | 170.0 |

TABLE 5-16. Comparison of Pollutant Concentrations Matrix to Matrix Over Sampling Period

| Plant | Soil vs Shoot | Soil vs Root | Root vs Shoot | Matrix Relationship |
|-------------------------|---------------|--------------|---------------|---------------------|
| TPH | | | | |
| <i>Iris pseudacorus</i> | 0.110 | 0.000 | 0.000 | root > soil = shoot |
| <i>Typha latifolia</i> | 0.000 | 0.840 | 0.000 | soil = root > shoot |
| <i>Sparganium sp.</i> | 0.010 | 0.790 | 0.000 | soil = root > shoot |
| <i>Scirpus acutus</i> | 0.005 | 0.270 | 0.000 | soil = root > shoot |
| <i>Eleocharis ovata</i> | 0.002 | 0.820 | 0.001 | soil = root > shoot |
| Pb | | | | |
| <i>Iris pseudacorus</i> | 0.000 | 0.000 | 0.017 | soil > root > shoot |
| <i>Typha latifolia</i> | 0.000 | 0.000 | 0.000 | soil > root > shoot |
| <i>Sparganium sp.</i> | 0.000 | 0.740 | 0.000 | soil = root > shoot |
| <i>Scirpus acutus</i> | 0.000 | 0.000 | 0.017 | soil > root > shoot |
| <i>Eleocharis ovata</i> | 0.000 | 0.099 | 0.000 | soil = root > shoot |
| Zn | | | | |
| <i>Iris pseudacorus</i> | 0.000 | 0.000 | 0.170 | soil > shoot = root |
| <i>Typha latifolia</i> | 0.000 | 0.000 | 0.002 | soil > root > shoot |
| <i>Sparganium sp.</i> | 0.400 | 0.120 | 0.010 | root = soil > shoot |
| <i>Scirpus acutus</i> | 0.000 | 0.000 | 0.003 | soil > root > shoot |
| <i>Eleocharis ovata</i> | 0.000 | 0.290 | 0.007 | soil = root > shoot |

bioaccumulation by *Iris pseudacorus* root tissues. Shoot tissues contained the lowest mean pollutant levels regardless of species, with the exception, again, of *Iris pseudacorus*, whose mean root and shoot zinc concentrations were roughly equal.

T-tests indicated that soil and root levels of TPH for all species did not differ meaningfully from each other except for *Iris pseudacorus* root tissues, as mentioned previously. This might suggest at least passive, if not active, bioaccumulation on the part of these species. T-tests also revealed no apparent preferential uptake of lead or zinc for any plant tissues. *Sparganium sp.* and *Eleocharis ovata* displayed no significant variation between soil and root concentrations of lead and zinc, indicating some capacity for bioaccumulation of these metals.

BIOMASS VARIATIONS

Biomass per unit area measurements were obtained at the end of the growing season in November 1991 (Table 5-17). Considered separately, *Typha latifolia* root and shoot tissues yielded the most biomass per unit area of all root and shoot tissues (Table 5-18). For *Typha latifolia* shoot biomasses, the comparison was significant in all cases ($p < 0.001$ or $p < 0.05$). For *Typha latifolia* root biomass, however, the significance was not across the board, with *Iris pseudacorus* and *Scirpus* root biomass not significantly departing from *Typha* root biomass measurements (Table 5-19).

TABLE 5-17. T-Test Probability Values for Total Plant Mass Per Area Between Species

| Plant | <i>Iris pseudacorus</i> | <i>Typha latifolia</i> | <i>Sparganium sp.</i> | <i>Scirpus acutus</i> |
|-------------------------|-------------------------|------------------------|-----------------------|-----------------------|
| <i>Typha latifolia</i> | 0.018 | | | |
| <i>Sparganium sp.</i> | 0.000 | 0.000 | | |
| <i>Scirpus acutus</i> | 0.320 | 0.004 | 0.000 | |
| <i>Eleocharis ovata</i> | 0.006 | 0.001 | 0.570 | 0.011 |

TABLE 5-18. Mean Pollutant Loadings Adjusted for Biomass Per Plant Matrix

| Plant | Mean Mass/Area (kg/m ²) | Mean TPH (g/m ²) | Mean Pb (g/m ²) | Mean Zn (g/m ²) |
|-------------------------------|-------------------------------------|------------------------------|-----------------------------|-----------------------------|
| <i>Iris pseudacorus</i> root | 2.56 | 4.01 | 0.007 | 0.045 |
| <i>Iris pseudacorus</i> shoot | 1.41 | 0.86 | 0.002 | 0.019 |
| <i>Typha latifolia</i> root | 3.16 | 7.90 | 0.042 | 0.314 |
| <i>Typha latifolia</i> shoot | 4.86 | 2.06 | 0.007 | 0.153 |
| <i>Sparganium sp.</i> root | 0.21 | 0.40 | 0.014 | 0.064 |
| <i>Sparganium sp.</i> shoot | 0.42 | 0.38 | 0.005 | 0.076 |
| <i>Scirpus acutus</i> root | 1.67 | 2.26 | 0.008 | 0.053 |
| <i>Scirpus acutus</i> shoot | 1.46 | 0.54 | 0.002 | 0.018 |
| <i>Eleocharis ovata</i> root | 0.17 | 0.31 | 0.008 | 0.029 |
| <i>Eleocharis ovata</i> shoot | 0.81 | 0.43 | 0.004 | 0.070 |

TABLE 5-19. T-Test Probability Values for Plant Mass Per Area Per Matrix Between Species

| Matrix | <i>Iris pseudacorus</i> Root | <i>Iris pseudacorus</i> Shoot | <i>Typha latifolia</i> Root | <i>Typha latifolia</i> Shoot | <i>Sparganium</i> sp. Root | <i>Sparganium</i> sp. Shoot | <i>Scirpus acutus</i> Root | <i>Scirpus acutus</i> Shoot | <i>Eleocharis ovata</i> Root |
|-------------------------------|------------------------------|-------------------------------|-----------------------------|------------------------------|----------------------------|-----------------------------|----------------------------|-----------------------------|------------------------------|
| <i>Iris pseudacorus</i> Root | 0.098 | | | | | | | | |
| <i>Typha latifolia</i> Root | 0.640 | 0.120 | | | | | | | |
| <i>Typha latifolia</i> Shoot | 0.087 | 0.027 | 0.250 | | | | | | |
| <i>Sparganium</i> sp. Root | 0.001 | 0.001 | 0.012 | 0.001 | | | | | |
| <i>Sparganium</i> sp. Shoot | 0.010 | 0.001 | 0.020 | 0.006 | 0.025 | | | | |
| <i>Scirpus acutus</i> Root | 0.210 | 0.600 | 0.180 | 0.031 | 0.012 | 0.025 | | | |
| <i>Scirpus acutus</i> Shoot | 0.096 | 0.650 | 0.130 | 0.025 | 0.003 | 0.002 | 0.071 | | |
| <i>Eleocharis ovata</i> Root | 0.001 | 0.001 | 0.010 | 0.001 | 0.330 | 0.016 | 0.011 | 0.002 | |
| <i>Eleocharis ovata</i> Shoot | 0.018 | 0.093 | 0.026 | 0.006 | 0.006 | 0.069 | 0.077 | 0.068 | 0.004 |

Using biomass per unit area measurements and mean pollutant concentration per unit weight, average pollutant loads per unit area were calculated separately for the roots and shoots of each species. Not surprisingly, *Typha latifolia* roots had the highest loadings per unit area for TPH, lead, and zinc, with 7.9, 0.042, and 0.134 g/m², respectively. *Iris pseudacorus* roots, followed by *Scirpus acutus* roots, were the next highest accumulators of TPH. *Sparganium sp.* roots and shoots, followed by *Eleocharis ovata* roots and shoots, retained the next most appreciable quantities of lead and zinc after *Typha latifolia*.

SOIL NITROGEN/PHOSPHORUS

Nitrogen and phosphorus in soils from the pond and the reference control sites were compared using Mann-Whitney "U" tests (Table 5-20). Nitrogen levels were higher at the control sites ($p < 0.001$), while phosphorus was markedly lower at the control sites ($p < 0.05$). Comparisons of the various reference control sites with the "U" test revealed no significant differences in nitrogen or phosphorus levels among them.

| TABLE 5-20. Soil Nitrogen and Phosphorus Concentrations Between the Pond and Selected Sites | | | |
|---|----------------------------|-------------------------------------|----------------------|
| Type of Concentration | Median Level in Pond (ppm) | Median Level at Selected Site (ppm) | Mann-Whitney p Value |
| Control Site | | | |
| Total Nitrogen | 1,200 | 14,500 | 0.000 |
| Total Phosphorus | 1,100 | 830 | 0.012 |
| Pacific Wetland Nursery | | | |
| Total Nitrogen | 1,200 | 2,250 | 0.156 |
| Total Phosphorus | 1,200 | 370 | 0.073 |
| Lower Cedar River | | | |
| Total Nitrogen | 1,400 | 16,000 | 0.010 |
| Total Phosphorus | 4,300 | 1,450 | 0.777 |
| Lake Sammamish | | | |
| Total Nitrogen | 1,200 | 15,500 | 0.000 |
| Total Phosphorus | 1,100 | 830 | 0.004 |